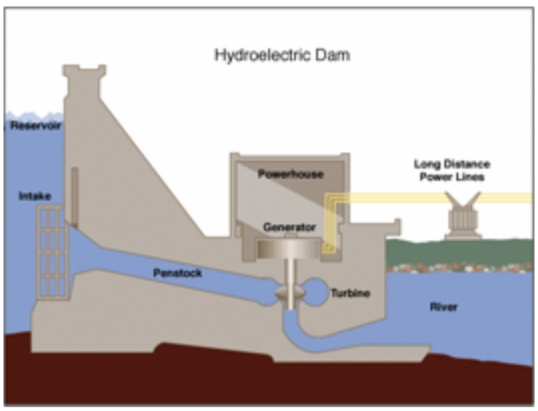
energy KIDS
Energy Information Administration

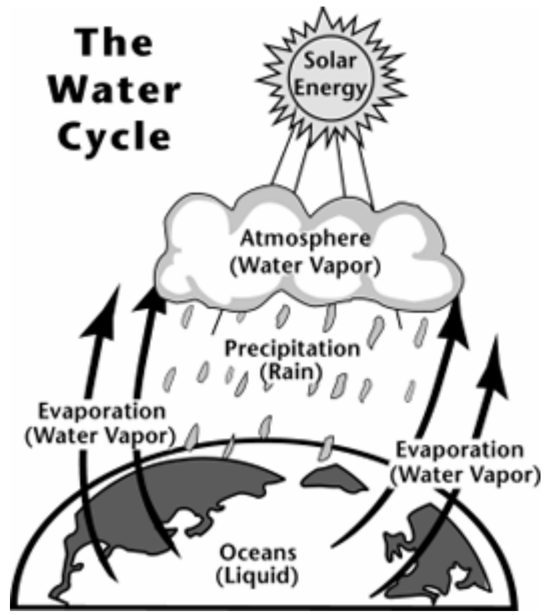
Renewable

Hydropower

Hydropower Basics

Energy From Moving Water





Hydropower Generates Electricity

Hydropower is the renewable energy source that produces the most electricity in the United States. It accounted for 6% of total U.S. electricity generation and 67% of generation from renewables in 2008.

Hydropower Relies on the Water Cycle

Understanding the water cycle is important to understanding hydropower. In the water cycle:

- Solar energy heats water on the surface, causing it to evaporate.
- This water vapor condenses into clouds and falls back onto the surface as

precipitation (rain, snow, etc.).
- The water flows through rivers back into the oceans, where it can evaporate and begin the cycle over again.

Mechanical Energy Is Harnessed from Moving Water

The amount of available energy in moving water is determined by its flow or fall. Swiftly flowing water in a big river, like the Columbia River that forms the the border between Oregon and Washington, carries a great deal of energy in its flow. Water descending rapidly from a very high point, like Niagara Falls in New York, also has lots of energy in its flow.

In either instance, the water flows through a pipe, or *penstock*, then pushes against and turns blades in a turbine to spin a generator to produce electricity. In a **run-of-the-river system**, the force of the current applies the needed pressure, while in a **storage system**, water is accumulated in reservoirs created by dams, then released as needed to generate electricity.

History of Hydropower

Hydropower is one of the oldest sources of energy. It was used thousands of years ago to turn a paddle wheel for purposes such as grinding grain. Our Nation's first industrial use of hydropower to generate electricity occurred in 1880, when 16 brush-arc lamps were powered using a water turbine at the Wolverine Chair Factory in Grand Rapids, Michigan.

The first U.S. hydroelectric power plant opened on the Fox River near Appleton, Wisconsin, on September 30, 1882.

Until that time, coal was the only fuel used to produce electricity. Because the source of hydropower is water, hydroelectric power plants must be located on a water source. Therefore, it wasn't until the technology to transmit electricity over long distances was developed that hydropower became widely used.

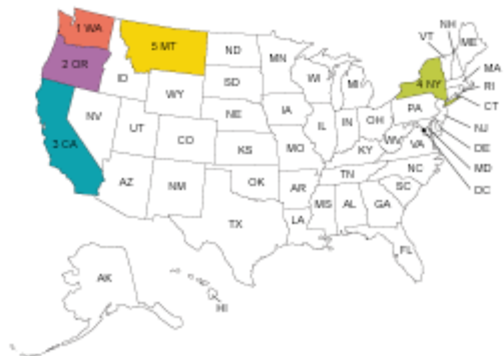
For more information about hydropower, see Hoover Dam, a hydroelectric facility completed in 1936 on the Colorado River between Arizona and Nevada. this dam created Lake Mead, a 110-mile-long national recreational area that offers water sports and fishing in a desert setting.

Where Hydropower is Generated

Most U.S. Hydropower Is in the West

Over half of U.S. hydroelectric capacity for electricity generation is concentrated in three States: Washington, California, and Oregon. Approximately 31% of the total U.S. hydropower is generated in Washington, the location of the Nation's largest hydroelectric facility — the Grand Coulee Dam.

Top Hydropower Producing States 2007



Source: Energy Information Administration, *Renewable Energy Trends in Consumption and Electricity, 2007 Statistics*, Table 1.18 (April 2009).

Data for this map

Most hydropower is produced at large facilities built by the Federal Government, such as the Grand Coulee Dam. The West has most of the largest dams, but there are numerous smaller facilities operating around the country.

Most Dams Were Not Built for Power

Only a small percentage of all dams in the United States produce electricity. Most dams were constructed solely to provide irrigation and flood control.

Hydropower & the Environment

Hydropower Is Nonpolluting, but Does Have Environmental Impacts

Hydropower does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area.

Most hydroelectric power plants have a dam and a reservoir. These structures may obstruct fish migration and affect their populations. Operating a hydroelectric power plant may also change the water temperature and the river's flow. These changes may harm native plants and animals in the river and on land.

Fish Ladder at the Bonneville Dam on the Columbia River Separating Washington and Oregon

Reservoirs may cover people's homes, important natural areas, agricultural land, and archeological sites. So building dams can require relocating people. Methane, a strong greenhouse gas, may also form in some reservoirs and be emitted to the atmosphere.

Fish Ladders Help Salmon Reach Their Spawning Grounds

In the Columbia River, along the border of Oregon and Washington, salmon must swim upstream to their spawning grounds to reproduce, but the series of dams gets in their way. Different approaches to fixing this problem have been used, including the construction of "fish ladders" which help the salmon "step up" the dam to the spawning grounds upstream.

Tidal Power

Tides are caused by the gravitational pull of the moon and sun, and the rotation of the Earth. Near shore, water levels can vary up to 40 feet due to tides.

Tidal power is more predictable than wind energy and solar power. A large enough tidal range — 10 feet — is needed to produce tidal energy economically.

Dam of the Tidal Power Plant on the Estuary of the Rance River, Bretagne, France

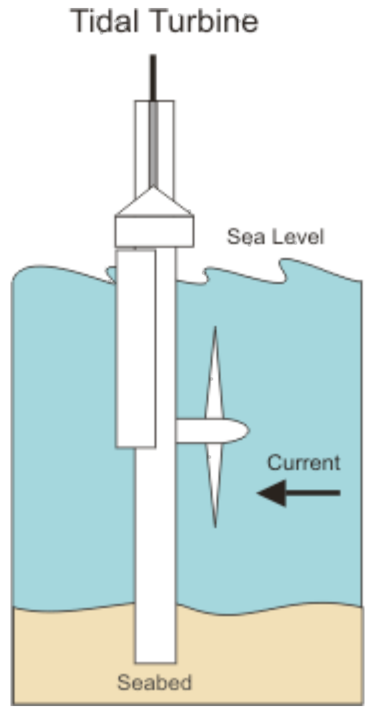
Tidal Barrages

A simple generation system for tidal plants involves a dam, known as a barrage, across an inlet. Sluice gates (gates commonly used to control water levels and flow rates) on the barrage allow the tidal basin to fill on the incoming high tides and to empty through the turbine system on the outgoing tide, also known as the ebb tide. There are two-way systems that generate electricity on both the incoming and outgoing tides.

A potential disadvantage of tidal power is the effect a tidal station can have on plants and animals in the estuaries. Tidal barrages can change the tidal level in the basin and increase turbidity (the amount of matter in suspension in the water). They can also affect navigation and recreation.

There are currently two commercial-sized barrages operating in the world. One is located in La Rance, France; the other is in Annapolis Royal, Nova Scotia, Canada. There is a third experimental 400 kW tidal barrage operating in Kislaya Guba, Russia.

The United States has no tidal plants and only a few sites where tidal energy could be produced economically. France, England, Canada, and Russia have much more potential to use this type of energy.



Tidal Fences

Tidal fences can also harness the energy of tides. A tidal fence has vertical axis turbines mounted in a fence. All the water that passes is forced through the turbines. Tidal fences can be used in areas such as channels between two landmasses. Tidal fences are cheaper to install than tidal barrages and have less impact on the environment than tidal barrages, although they can disrupt the movement of large marine animals.

A tidal fence is planned for the San Bernardino Strait in the Philippines.

Tidal Turbines

Tidal turbines are basically wind turbines in the water that can be located anywhere there is strong tidal flow. Because water is about 800 times denser than air, tidal turbines have to be much sturdier than wind turbines. Tidal turbines are heavier and more expensive to build but capture more energy.

Wave Power

Waves Have Lots of Energy

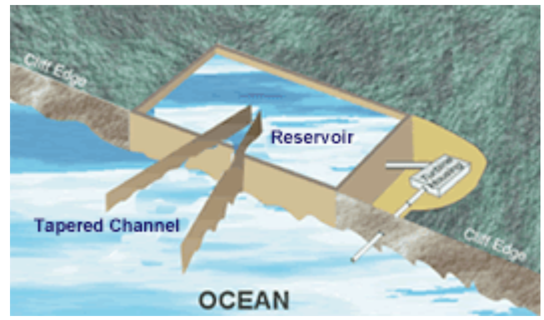
Waves are caused by the wind blowing over the surface of the ocean. There is tremendous energy in the ocean waves. It's estimated that the total potential off the coast of the United States is 252 billion kilowatthours a year, about 7% of the United States' electricity consumption in 2008. The west coasts of the United

States and Europe and the coasts of Japan and New Zealand are good sites for harnessing wave energy.

Different Ways To Channel the Power of Waves

One way to harness wave energy is to bend or focus the waves into a narrow channel, increasing their power and size. The waves can then be channeled into a catch basin or used directly to spin turbines.

Diagram of a Wave Energy Site



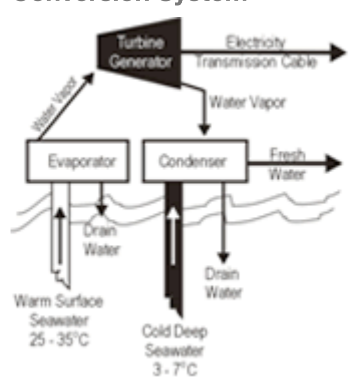
Many more ways to capture wave energy are currently under development. Some of these devices being developed are placed underwater, anchored to the ocean floor, while others ride on top of the waves. The world's first commercial wave farm using one such technology opened in 2008 at the Aguçadora Wave Park in Portugal.

See all the technologies under development at the U.S. Department of Energy's [Marine and Hydrokinetic Technology Database].

Ocean Thermal

The energy from the sun heats the surface water of the ocean. In tropical regions, the surface water can be much warmer than the deep water. This temperature difference can be used to produce electricity. The Ocean Thermal Energy Conversion (OTEC) system must have a large temperature difference of at least 77°F to operate, limiting its use to tropical regions.

Diagram of an Ocean Thermal Energy Conversion System



Hawaii has experimented with OTEC since the 1970s. There is no large-scale operation of OTEC today, mainly because there are many challenges. The OTEC systems are not very energy efficient. Pumping water is a major engineering challenge.

Electricity generated by the system must be transported to land. It will probably be 10 to 20 years before the technology is available to produce and transmit electricity economically from OTEC systems.

EIA does not forecast the commercialization of OTEC systems in its most recent Annual Energy Outlook (March 2009). However, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy is currently funding research and development on OTEC cold water pipe manufacturing techniques to help create a more cost-effective OTEC system.